

1. INTRODUCTION

The SpaceX-16 "Dragon" cargo ship was released from the International Space Station (ISS) on GMT 2019-01-13 at about 23:33. This was the first splashdown and recovery at night for the Dragon. The commercial cargo vehicle returned a variety of space research that will be handed off to NASA engineers and distributed to investigators around the world.

SpaceX-16 Dragon completed a ~36-day mission attached to the station's Node 2 (Harmony) module after delivering several thousand pounds of science and supplies on GMT 2018-12-08. The departure of Dragon left four visiting vehicles, including Northrop Grumman's Cygnus cargo ship, attached to the space station as depicted in Figure 1.

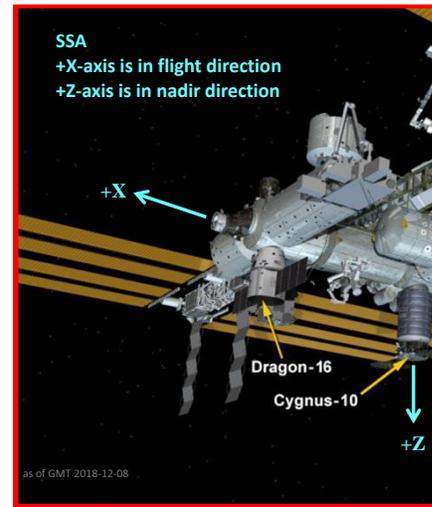
If all goes as planned, then the next Dragon mission to the space station will be SpaceX's first vehicle capable of transporting crew to the ISS. However, this first one will be an uncrewed demonstration mission, designated SpaceX DM-1, to verify readiness of ground systems, orbit-to-docking activities and landing operations.

2. QUALIFY

Figure 2 on page 2 is a color spectrogram computed from Space Acceleration Measurement System (SAMS) sensor 121f05 measurements made in the Japanese Experiment Module (JEM) during the unberth and release activities. The arrow annotation shows some of the vibratory impact related to those activities. At GMT 22:45, attitude control was transitioned to US-only thruster (USTO) mode of operation resulting in a train of impulsive accelerations that tend to excite structural modes below about 2 Hz. These vibrations show up initially as vertical, yellowish streaks on the spectrogram followed by brief orange/red horizontal streaks until the excitation (spectral peaks) settles down. Attitude is held leading up to Dragon release at ~GMT 23:31, then USTO pattern mentioned earlier is repeated starting at GMT 23:39.

3. QUANTIFY

The Microgravity Acceleration Measurement System (MAMS) would have been the instrument to best measure the quasi-steady effects of the unberth/release of Dragon and the shift of overall ISS center of mass. However, the MAMS was out of service during these events, so here we take a look at low-pass filtered SAMS data in an attempt to quantify the vibratory impact.



The cropped image in the red rectangle at the left shows the location of the "Dragon-16" cargo ship before unberthing.

The larger image below shows the vacated nadir port of Node 2 after Dragon departure.

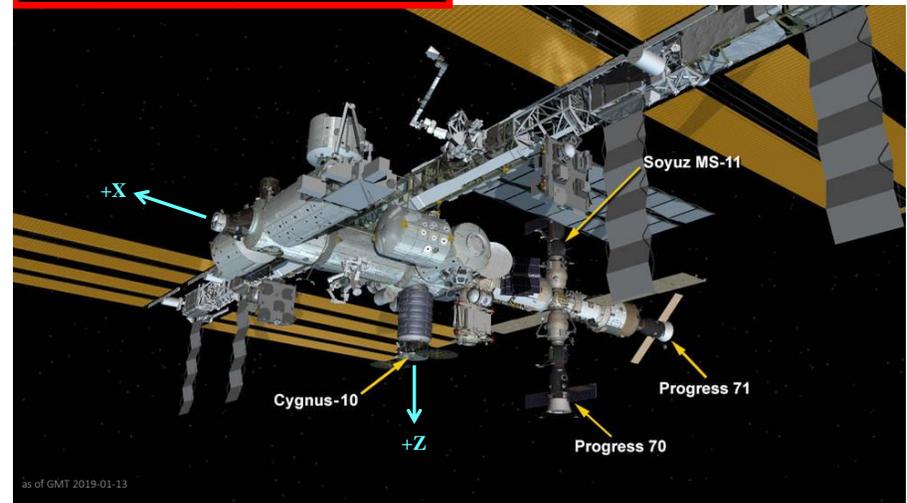


Fig. 1: Visiting vehicle arrangement before (top) & after (bottom) Dragon departure.

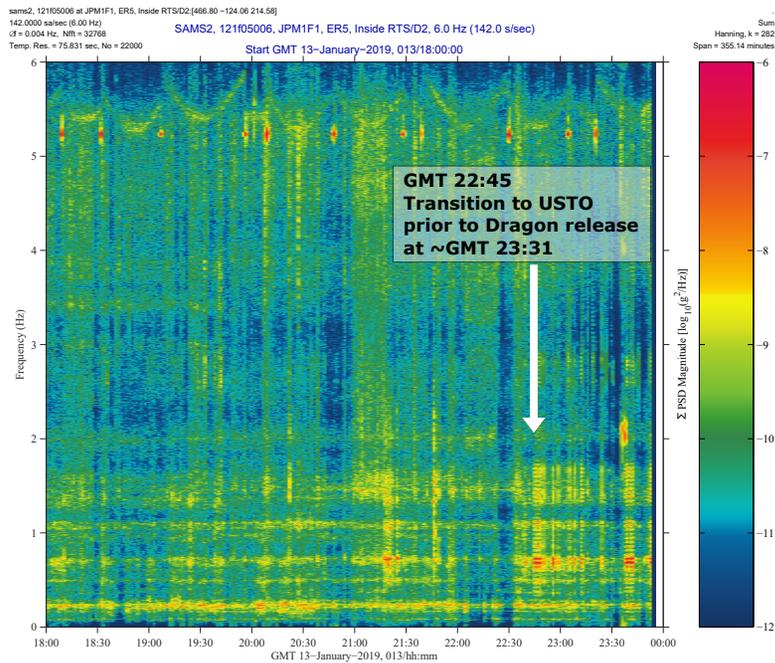


Fig. 2: Spectrogram during Dragon unberth/release activities on GMT 2019-01-13.

Figure 3 on page 3 shows acceleration Root-Mean-Square (RMS) values versus time. These RMS values (below 2 Hz) were computed from SAMS sensor 121f02 measurements made in the JEM during the same span as the spectrogram of Figure 2. As the 2 annotations on that page show, there were notably large impacts during the 2 spans when USTO was used to control attitude before and after Dragon release. The unberth and release events do not show as impactful to the transient/vibratory environment. Instead, the maneuvering and attitude control required to orchestrate a clean and safe departure are where we focus for transient and vibratory impacts as shown in Figure 3 through Figure 5 for SAMS sensors in the JEM, Columbus and US Lab modules, respectively.

RMS values below 2 Hz in the Columbus module topped out just under $250 \mu\text{g}$ during USTO control as seen in Figure 4. On the other end of the RMS magnitude

scale, the smallest impact was in the US LAB at about $75 \mu\text{g}$, see Figure 5.

4. CONCLUSION

The RMS results presented here reinforce the fact that SAMS sensors in the JEM and COL tend to experience higher magnitude structural mode excitation than those in the US LAB due to the layout, structure and nature of the ISS. In the case of a Dragon release as described in this document, the driving force and source of excitation were thrusters needed to change or maintain the space station's attitude, primarily before and after the actual release event.

